UV solar cells based on Mg-doped hydrogenated GaN on glass substrates grown at 380℃

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To extend the application of nitrides in low-cost and large-area optoelectronics devices, it is necessary to grow the crystals on various substrates under lower temperatures. Candidate materials for the above purpose are microcrystalline nitrides grown at low temperatures. For optoelectric application of the materials, hydrogen atoms are required to passivate dangling bonds and defects at the interface of crystallites and dislocations.

We have reported that hydrogenated microcrystalline GaN grown by dual remote-plasma MOCVD at 300℃, incorporates 17-30% of hydrogen as Ga-H and N-H bonds, and the passivation by hydrogen significantly improves the photoelectrical properties of the films[1)] and also that Mg-doped hydrogenated GaN (GaN:H,Mg) films on aluminum substrates grown at 380℃ show excellent photoelectrical properties as visible blind UV-sensors. [2)]

In this study, GaN:H,Mg films are fabricated on transparent conductive glass substrates in order to exhibit a feasibility of transparent UV solar cells. The details of the dual remote-plasma MOCVD system and the conditions are described elsewhere.[1,2]

Photodiodes were fabricated in the sandwich configuration of glass/ITO/Mg-doped GaN:H/Au. A semitransparent Au electrode of 3 mm diameter with 35% to 50% transmittance was evaporated onto the film.(Fig.1) All GaN:H:Mg films are transparent with an absorption edge at around 400 nm. The device looks through in light blue. Mg-doped GaN:H films reveal a clear columnar structure of 30 – 50 nm diameter. The films have an almost stoichiometric N/Ga ratio of 1.1. The hydrogen content of the Mg doped GaN:H was measured as 6 - 8 atomic %. The infrared absorption peaks of Ga-H and N-H increased slightly as a results of the Mg doping. However, absorption bands resulting from Mg-H complexes have never been observed in our films.

The spectral response of the photocurrent of a device at 0V bias exposed from ITO electrode side to a monochromatic light of 10 μW/cm^2 is shown in Fig.2. A cutoff was observed over 360 nm wavelength. The maximum responsivity is 0.034 A/W at 360 nm, corresponding to a maximum internal quantum efficiency of more than 0.5. Open circuit voltage is 1.2V irradiated by 20mW He-Cd laser at 325nm. Maximum fill factor is 40% and maximum internal conversion efficiency is estimated to be 4% in this simple structure. The light intensity dependence of the photocurrent is unity at various wavelength (Fig.4).

In conclusion, The fabricated Mg-doped GaN:H films on glass substrates have excellent photosensitivity in photovoltaic mode. The application in a transparent solar cell for UV light is exhibited for the films.

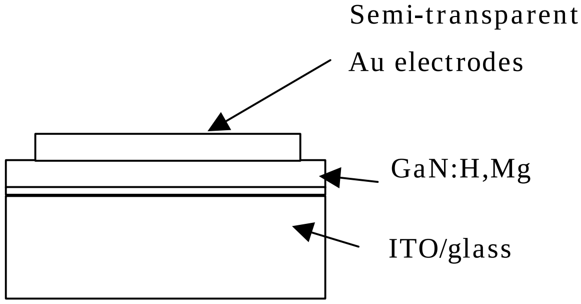

Fig.1 Schematic of glass/ITO/GaN:H,Mg/Au Device

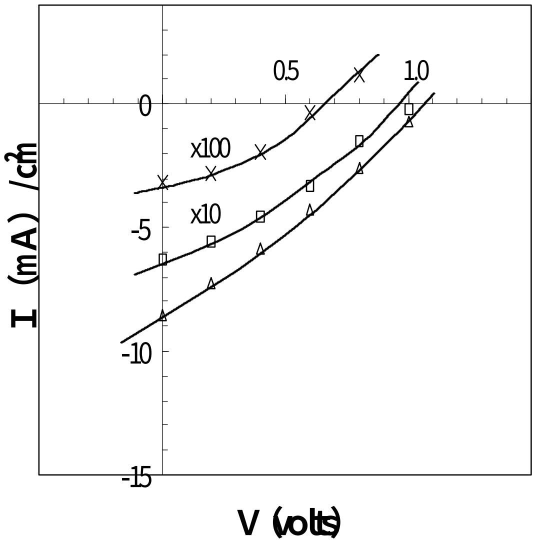

Fig. 3 Photocurrent of Glass/ITO/GaN:H,Mg/Au device under various intensity of 325nm irradiation from 20mW He-Cd laser. Maximum fill factor is 40%.

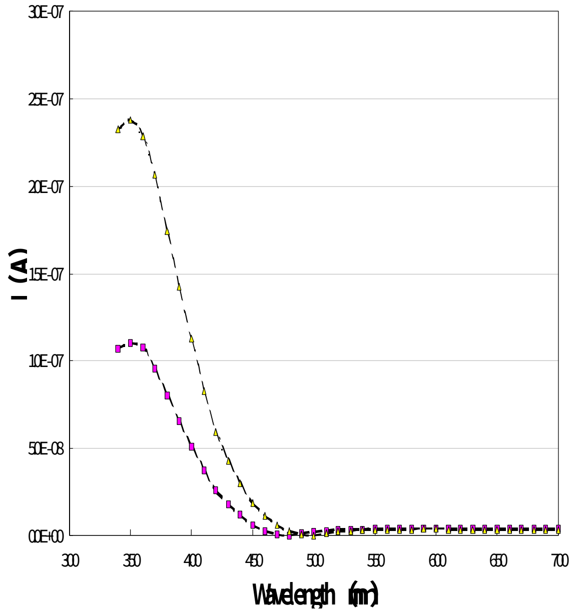

Fig.2 Spectral photoresponse of an glass/ITO/GaN:H,Mg/Au devise biased at 0V under constant intensity of 3.5 μW and 7 μW.

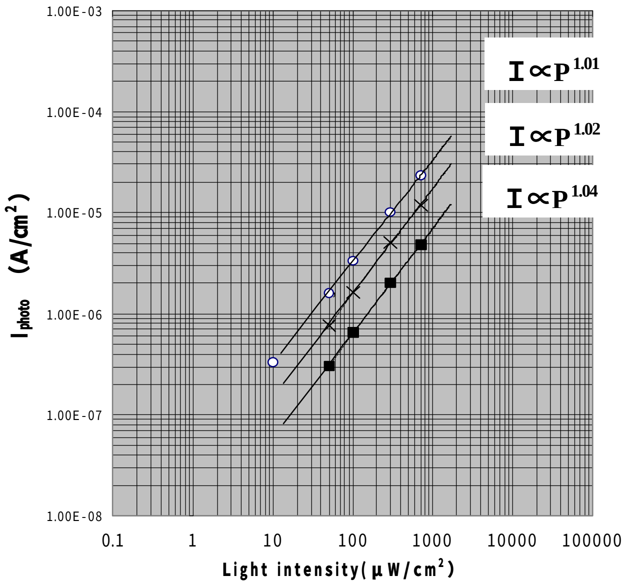

Fig.4 Wavelength dependence of short circuit current of glass/ITO/GaN:H,Mg/Au irradiated at 360nm(○),400nm(×) and 430nm(■).

References
1.S.Yagi,Jpn.J.Appl.Phys.,Part2 38,L792(1999).
2. S.Yagi,Appl.Phys.Lett.,76,345(2000).